1,102,832

# PATENT SPECIFICATION

DRAWINGS ATTACHED

1,102,832

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Int. Cl.:—H 05 k 3/10.

COMPLETE SPECIFICATION

## Improvements in or relating to the Manufacture of Thin Film Modules

WE, THE MARCONI COMPANY LIMITED, English Electric House, Strand, London, W.C.2., a British Company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:

This invention relates to the manufacture of thin film modules of the kind wherein circuit elements, or parts thereof, and interconnections therefor are formed by the deposition of materials through masks on to a substrate of glass or other suitable material.

There are at present two main methods of depositing materials through masks. The first of these methods involves the use of discrete masks for each material each mask consisting of a sheet of metal etched to form a stencil for the required pattern of the material to be deposited. The mask is supported close to but spaced from the substrate and the material to be deposited is evaporated in vacuo through the mask on to the substrate. This first method suffers from the disadvantage that the accuracy of the pattern etched in the mask is limited by the thickness of the mask which has to be sufficiently thick to be self-supporting. Furthermore, the need to keep the mask as thin as possible, yet self-supporting, seriously limits the size and configuration of the pattern in the mask.

The second of the two methods involves the use of what are termed "in-contact" masks. The mask in this case is formed by depositing a continuous layer of copper or other suitable material on to the substrate itself and forming the mask by etching the required pattern in the layer selectively to expose the substrate. The required material is then deposited over the mask and exposed substrate, and the mask together with the material thereon is removed in a suitable etching bath leaving in position the material which has been deposited through the mask directly on the substrate. This second method suffers from the disadvantage that great care must be taken to ensure that over areas where no material is required to be deposited, the mask is without defects such as pinholes through which unwanted deposition of material could occur. This second method also suffers from a serious practical disadvantage, which arises in those common cases in which different parts of the deposit on the substrate are required to be of different materials (e.g. parts of sensitive material and other parts of conductive material) and accordingly a succession of deposition steps, each with a different deposited material, has to be effected. This disadvantage is that after each step the module has to be removed from the vacuum in which deposition is effected and placed in an etching bath to remove the copper mask together with any material on it. This, in effect, involves that each step is a virtually complete process, for the removal of the first etched mask on and through which the first material has been deposited has to be followed by the depositing and etching and subsequent removal of another mask on and through which the second material is deposited . . . and so on. In the manufacture of a quite average module there will be required to be deposited at least three different materials, one material, usually gold, for the interconnection conductors and capacitor plates, a second material, often nickel chromium, for the resistors and a third material, commonly silicon monoxide, for the dielectric of the capacitors. The module, therefore has twice to be cleaned in the

etching bath between deposition processes, and again when the final material has been deposited so that the whole process is lengthy and expensive to practise.

It is an object of this invention to provide an improved method of manufacturing thin film circuit modules of the kind referred to and wherein different parts of the deposition on the substrate of the finished module are required to be of different materials, which do not suffer from the disadvantages outlined above.

According to this invention a method of manufacturing a thin module includes at least the steps of forming on a face of a substrate an in-contact mask having a pattern corresponding to a final pattern required on the substrate of the module and serving to determine said final pattern; masking off a desired portion of said in-contact mask with a discrete mask; depositing a first material through the discrete mask and the in-contact mask on to the substrate; masking off another desired portion of said in-contact mask with a discrete mask; depositing another material through the in-contact mask and the last-mentioned discrete mask; and removing the in-contact mask with any deposited material thereon. As many steps of depositing as may be required can be effected, each being made through a discrete mask and the same in-contact mask, which does not have to be removed until all the steps of deposition have been accomplished.

When the last of the materials has been deposited the module may be inserted in an etching bath to remove the in-contact mask together with any of the materials deposited thereon.

It will be seen that the said final pattern on the substrate will be of good accuracy everywhere for its accuracy is determined by the in-contact mask and not by the discrete masks used in conjunction therewith, the latter masks serving in effect merely to ensure that only a desired part of the in-contact mask is used for any particular deposition step and therefore being able to be made thick and with patterns of wide tolerance. Indeed, and preferably the dimensioning of the discrete mask patterning is made slightly larger than the dimensioning of the corresponding parts of the in-contact mask patterning at required places in order to ensure that at these places it is the discrete mask which determines the dimensioning of the patterning in the finished product.

In many cases it will be required that the final deposited pattern shall correspond exactly with the desired complete pattern in the finished module. However, in some cases, and particularly where capacitors are to be deposited, it may be required to deposit at the same place on the substrate successive layers of material which have different shapes and areas. In such cases the appropriate aperture in the in-contact mask is preferably such as to correspond to the overall shape and size of the final deposition and layers which have parts lying within said overall shape are defined on these parts not by the in-contact mask but by the respective discrete mask.

The invention is illustrated in the accompanying drawings in which Fig. 1 shows a plan view of one simple example of a module which may be manufactured in accordance with the present invention and Figs. 2, 3, 4, 5 and 6 illustrate the sequence of masks used in the manufacture of the module of Fig. 1.

Referring to Fig. 1, a thin film circuit module is shown comprising a substrate 1 of glass or other suitable material having deposited thereon a capacitor 2 (which consists of a lower plate 3 and an upper plate 4 separated by a layer 5 of dielectric material), strip resistors 6 (shown cross-hatched) and a number of connector conductors 7 to 10. The conductor 8 is integral with the lower plate 3 of the capacitor 2. In manufacturing the module shown in Fig. 1, a layer of copper is first deposited on the face of the substrate and a pattern corresponding to the complete pattern required on the finished module shown in Fig. 1 is etched through the copper layer to expose the surface of the substrate. Fig. 2 shows the copper layer 11 and the exposed substrate at 12. The pattern of exposed substrate 12 in Fig. 2 should be compared with the complete pattern comprising capacitor 2, resistors 6 and conductors 7 to 10 shown in Fig. 1, to which it corresponds exactly.

The first material of the module proper to be deposited in the present example is gold, which forms the bottom plate 3 of capacitor 2 and the conductors 8, 9 and 10. This is achieved by evaporating the gold in vacuo through the discrete mask 13 shown in Fig. 3. Mask 13 has a pattern corresponding to the pattern required of the deposited gold but of slightly increased dimensions to ensure that it is the in-contact mask 11 which determines the deposited pattern and not the mask 13. Mask 13 merely ensures that only the desired part of the in-contact mask is in use at this deposition step.

Mask 13 is then replaced by a discrete mask 14 shown in Fig. 4, and silicon monoxide, which in this example is the dielectric material of capacitor 2, is then evaporated in vacuo on to the substrate. The dimensions of the pattern in the mask 14 are slightly larger than those of the pattern required of the deposited dielectric

material.

Similar steps are then carried out using a mask 15 shown in Fig. 5 to deposit nickel chromium to form the resistors 6. To ensure good contact between resistors 6 and their connecting conductors 8, 9 and 10 the masks 13 and 15 are made such that there is an overlap between the resistors and conductors where contact is made.

A mask 16 shown in Fig. 6 is used to deposit the upper plate 4 of the condenser 2 and the remaining conductor 7.

In order to prevent short-circuiting between the capacitor plates it is necessary to ensure that the dielectric layer 5 appreciably exceeds the area of overlap between the plates 3 and 4. Mask 11 must be as large as the layer 5 and therefore the edges of the capacitor plates within the area of layer 5 are not defined by the in-contact mask, but by the discrete masks 13 and 16. In practice however this defect has a negligible effect.

The substrate is then removed from vacuo and etched in an etching bath in known manner to remove the copper in-contact mask together with any of the various materials deposited on it, leaving the required deposited materials in position on the substrate in accurately clear-cut patterns.

For the purposes of illustrating the present invention a simple circuit arrangement has been chosen but as will be apparent the present invention is not limited to simple circuits but has wide application generally in the manufacture of thin film modules wherein two or more different materials have to be deposited in patterns on a substrate. Furthermore other components such as inductors may be deposited with the use of a suitable mask. The resistive, conductive and dielectric materials as well as the mask materials recited in the above description are exemplary only and it is to be understood that any suitable materials can be used.

WHAT WE CLAIM IS :—

1. A method of making a thin film module said method including at least the steps of forming on a face of a substrate an in-contact mask having an aperture or apertures corresponding to a final circuit pattern required on the substrate of the module and serving to determine said final pattern ; masking off a desired portion of said in-contact mask with a discrete mask ; depositing a first material through the discrete mask and the in-contact mask on to the substrate ; masking off another desired portion of said in-contact mask with a discrete mask ; depositing another material through the in-contact mask and the last-mentioned discrete mask ; and removing the in-contact mask with any deposited material thereon.

2. A method as claimed in claim 1 and including at least one further step, effected before removal of the in-contact mask with any deposited material thereon, of masking off a further portion of the in-contact mask with a further discrete mask and depositing a further material through the same and through the said in-contact mask.

3. A method as claimed in claims 1 or 2 wherein the dimensioning of the discrete mask patterning is made slightly larger than that of the corresponding parts of the in-contact mask patterning at required places in order to ensure that at these places it is the discrete mask which determines the dimensioning of the patterning in the finished product.

4. A method as claimed in any of claims 1 to 3 wherein it is required to deposit at the same place on the substrate successive layers of material which have different shapes and areas and wherein the appropriate aperture in the in-contact mask is such as to correspond to the overall shape and size of the final deposition and layers which have parts lying within said overall shape are defined on these parts not by the in-contact mask but by the respective discrete mask.

5. Methods of making thin film modules substantially as herein set forth with reference to the accompanying drawings.

6. Thin film modules when made by a method as claimed in any of the preceding claims.

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Essex,
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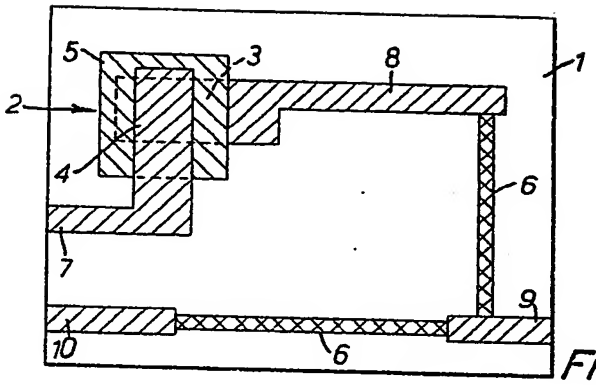


FIG. 1.

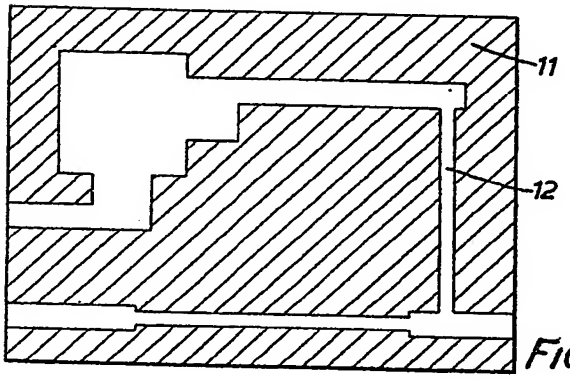


FIG. 2.

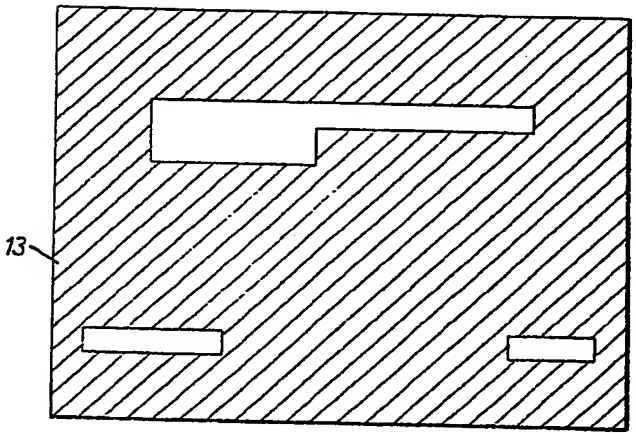


FIG 3

1,102,832 COMPLETE SPECIFICATION
2 SHEETS
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SHEETS 1 & 2

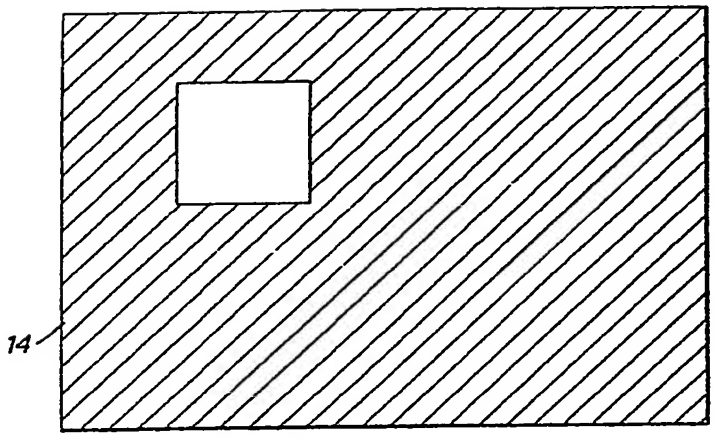


FIG. 4.

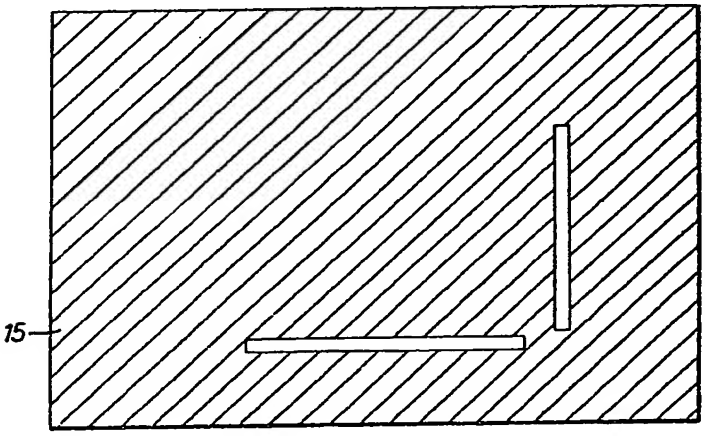


FIG. 5.

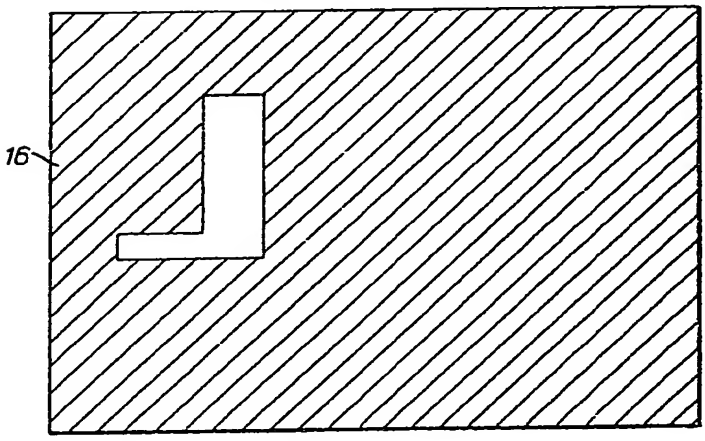


FIG. 6.

1,102,832 COMPLETE SPECIFICATION
2 SHEETS
This drawing is a reproduction of the Original on a reduced scale.
SHEETS 1 & 2

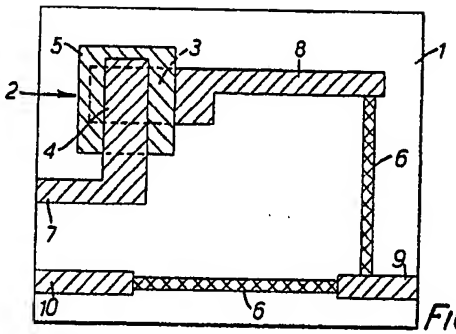


FIG. 1.

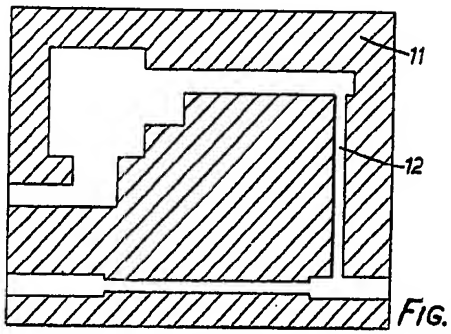


FIG. 2.

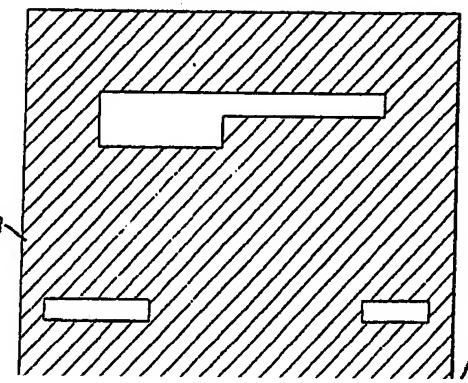


FIG 3

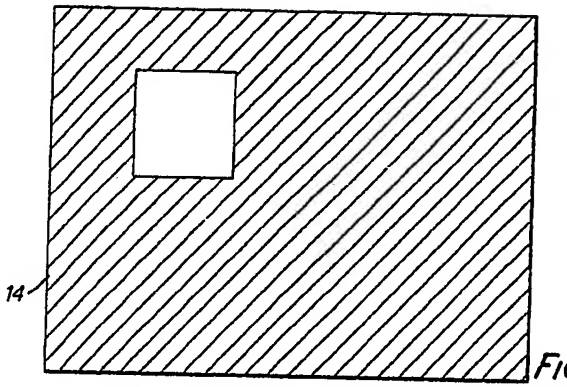


FIG. 4.

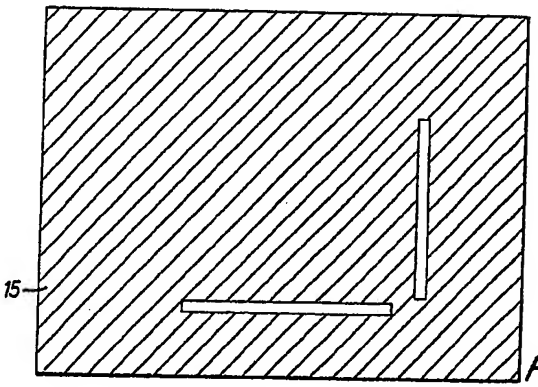


FIG. 5.

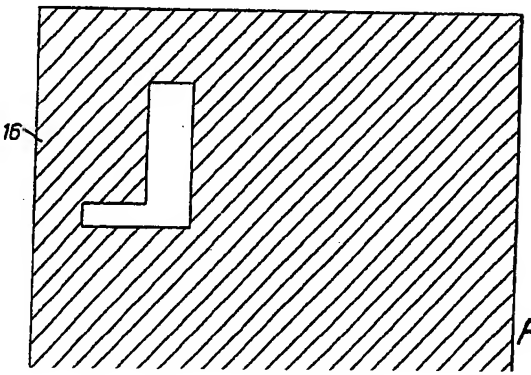


FIG. 6.